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## SOME PERILS WHICH CONFRONT US AS SCIENTISTS

By Professor FRANCIS B. SUMNER

SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH

TO play the rôle of Cassandra is commonly to invite unpopularity if not contempt. The average, easy-going mortal (which means some ninety per cent. or more of us) is by nature an optimist, and he does not wish his optimistic reveries to be disturbed by forecasts of impending disaster. However, Cassandra's prophesies were true and Troy did fall.

The dangers which I am about to discuss threaten all of us who seek to learn the ways of nature without ulterior motive. To realize these dangers is the first step toward averting them. That they are not generally realized is only too evident to one who reads either the editorial opinions of the daily press or the more learned deliverances of his own scientific colleagues.

The perils of which I am about to speak are all manifestations of one great fundamental Peril, whose source lies deep in our current habits of thought and in our philosophy of life. This has been variously designated as "commercialism," "materialism" and "utilitarianism." Each of these words expresses one aspect of the truth, though each in itself is incomplete. Taken etymologically, the word utilitarianism conveys most nearly the idea which I intend to express, though I do not wish to identify this meaning with the ethical theory which has been known by that name.

This habit of thought is characterized by the glorification of *utility*. Its standards of value are "usefulness," "practicality" and "efficiency," or, in its crassest form, dollars and cents. Its dearest foes are the "theorists," the "idealist" and the "doctrinaire."

The reader may be smiling, perhaps, at my tardy discovery of a conflict of ideals as old as civilization itself, and at the naïve way in which I am uttering these platitudes with all the authority of a Hebrew prophet. Well, let us admit that what I shall say contains nothing very new in principle. But is it not true that all reforms are made possible through the reiteration of more or less familiar ideas, until at last they gain ac-

ceptance and are translated into action? Moreover, even if the main theme of my discourse is hoary with antiquity, the present world situation is without parallel in the past, and the dangers of which I speak are particularly menacing at this time. This is the more true because they are not generally recognized as real.

By many it is being joyfully proclaimed that science has at last come to its own. Has not the Great War shown to all the world, and shown with unmistakable clearness, the practical value of science to the nation? Has not the scientist in nearly every field of knowledge—the psychologist and the astronomer, no less than the chemist, the physicist and the bacteriologist—been called upon to play a vital part in the defense of his country and of civilization? That he has answered this call with credit to himself and his profession is one of the outstanding features of recent history. Professors and doctors of philosophy are now majors and captains in the army. The importance and variety of the services which they have rendered can not even be suggested in the space at my disposal. They have been interestingly summarized in various recent addresses and magazine articles.<sup>1</sup>

So far, this is all as it should be. That a scientist whose special training enabled him to aid materially in the national defense should have failed to devote his energies to this task in such a crisis would assuredly have betrayed a lack of elementary patriotism. And the depleted faculties of our universities are testimony enough that the call when it came was not unheeded. Indeed it now seems probable that this outburst of collective enthusiasm led many to drop valuable investigations of long standing and to embark upon unknown seas, in quest of very problematic returns. Be this as it may, the net results of this movement were of great and obvious importance to the nation.

Thus it comes to pass that even the man in the street no longer views the spectacled professor with the undisguised contempt of former years. The "high-brow" has at last made good. He has done something *useful*! So it may well be that within the next few years the professor will be able to meet his classes in garments a little less threadbare than heretofore, and that he will not need to beg quite so hard for the meager allowance upon which to run his laboratory. I even suspect that the legislator will now and then find himself besieged by

<sup>1</sup> For example, the article by Professor J. S. Ames in *Science*, October 25, 1918.

taxpayers, clamoring for the more generous treatment of so useful a citizen.

At such times as this the embarrassed scientist might well have recourse to the prayer: "Lord save me from my friends!" For it is to be feared that in his case, popular favor must rest largely upon a misconception of his real aims, and that it can only be sustained by tenderly nursing this misconception. Herein lies his greatest temptation. Will not the scientist come to listen more often than in the past to those siren voices which promise him financial support and social recognition? The investigator who accepts these with the tacit understanding that direct or indirect practical results are to follow from his labors is likely to find himself confronted by a dilemma. Either he will adhere to these conditions conscientiously, in which case his outlook and freedom of action will be seriously restricted, or he will fail to observe them scrupulously, and thus blunt that spirit of truthfulness which is his most potent instrument of research. Furthermore, he will sooner or later face the inevitable day of reckoning which will follow his failure to "deliver the goods."

At this point certain words of explanation may be necessary. I regard all work in science as being justified by its *value to humanity*. I should apply to it the same standard as to music, art or literature. If there really exists anywhere a scientist who works solely for the gratification of his personal appetite for knowledge, and who glories in the utter uselessness of his intellectual output to mankind, his suppression by society would be altogether justifiable. This is the more true since such a being would not merit the name of scientist. Science is, by nature, a social function. But such a grotesque caricature probably does not exist, at least outside of a lunatic asylum or the pages of comic literature.

Let us repeat then, science must be justified by its value to mankind. But we must recognize the existence of various standards of value. That there are standards far higher than those generally recognized and applied to this question is the main theme of my discourse.

A further word of explanation is desirable. I have no sympathy with the scientist—if such a one indeed exists—who regards scientific knowledge as being *tainted* by its application to the practical needs of life. The task of utilizing the forces of nature to the fullest, whether in saving our labors, increasing our pleasures or diminishing our pains, should be pursued relentlessly. And the student of nature who turns aside from

his quest for truth to offer his assistance in the making of any such practical application does not necessarily degrade himself or compromise his scientific ideals.

But here again we are probably dealing with a caricature rather than a reality. However that may be, the caricature is one that has so often been drawn that many in our midst have perhaps been led to believe in its actual existence. The real element of truth in the picture is the recognition by some of us of the dangers which may beset the path of the investigator who endeavors to combine "pure" and "applied" science. One of these dangers, already referred to, is the acceptance of financial support under conditions which must limit the investigator's freedom of action. Another is the insidious impairment of his intellectual honesty which sometimes results from an endeavor to cooperate with those who may entertain widely different standards of value and of truthfulness from himself.

We must now look a little further into this matter of standards of value. There was a time, early in my own life, when I decided for certain reasons to abandon the pursuit of biology as a profession and to study medicine. I well remember the warm approbation with which my decision was greeted by certain high-minded relatives of mine, on the ground that I should henceforth be working for the benefit of humanity. To merely extend the boundaries of knowledge seemed too much like a selfish pastime. Yet it is doubtful if selfishness of motive would have been imputed, had I shown talent along artistic lines and chosen the career of poet, musician or painter. The need of "applying" these latter gifts in any special way to the "benefit of humanity" is seldom insisted upon, at least by educated persons. They are, in themselves, credited with being elevating to mankind, and the artist's only duty in the matter would seem to be to give (or sell!) his creations to the public. Fortunately, as I now believe, I once more reversed my decision and have ever since continued unrepentingly in the humble quest of scientific truth.

In passing, one can not refrain from paying his respects to an educational system which refuses to recognize the cultural value of science, and which treats it—when it does not ignore it altogether—as consisting merely of useful precepts regarding the preservation of health or the basic principles underlying this or that skilled profession.

But in the long run, the scientist himself can not altogether escape responsibility for these misconceptions. He commonly recognizes no obligation to enlighten the public regarding his

activities, and when he does so he is only too apt to shamefacedly hide from view the real sources of his inspiration and to talk the same utilitarian lingo as the world around him. And from talking it, he may more and more come to believe in it.<sup>2</sup>

Much of the current defense of science, as voiced by some of its acknowledged spokesmen, and by the editors of some of our foremost scientific journals, seems to me to be sadly one-sided, if not actually disingenuous. We are quite prepared to hear our manufacturers talk of science as the "handmaid of industry," but it gives us something of a shock to find such an utterance as the following quoted with approval by one of our foremost astronomers. "Without the aid of science," we are told, "the arts would be contemptible; without practical application, science would consist only of barren theories, which men would have no motive to pursue."<sup>3</sup>

Let us grant that, other things equal, the scientific discovery which admits of practical application is of greater importance to mankind than one which admits of no such application. In other words, the practical application may bestow a certain added value upon an otherwise important discovery. But this is far different from making practical applicability the sole criterion of the importance of a given bit of knowledge. One might well seek for the *practical applications* of the Copernican theory of the heavens, or the doctrine of organic evolution, albeit both of these hypotheses have revolutionized our habits of thought and our outlook upon the world in which we live.

I can not admit for a moment, indeed I feel it my duty to combat with whatever force and logic I can muster, the contention that practical applicability, in any commonly accepted meaning of the terms, is to be regarded as the fundamental standard of value in judging of the importance of scientific discoveries. If the meaning of these terms is to be so extended as to cover any form of benefits, mental, moral or material, which may accrue to mankind from the growth of natural knowledge, we could, of course, no longer reject this as the all-sufficient standard of value. But such a perversion of meaning would not make for the interests of clear thinking. Far from it, we should confuse an issue which is now a tolerably clear one.

<sup>2</sup> See the quite pertinent remarks of Dr. W. J. Crozier on this subject (*Science*, August 23, 1918).

<sup>3</sup> Quoted by Dr. George E. Hale, in an address under the auspices of the Engineering Foundation (*Science*, November 22, 1918).

In an extremely interesting recent volume, entitled "Science and the Nation,"<sup>4</sup> there are brought together the views of more than a dozen prominent English investigators, chosen from nearly as many different fields of pure and applied science. The writers herein consider this very question of the outlook for "pure" science after the war. Each of them insists upon the necessity for a fuller recognition of science by the nation, if the British Empire is to maintain its preeminent position in the world. Some of them are eloquent in demanding absolute freedom for the investigator to pursue his researches, regardless of their practical consequences. It is refreshing, for example, to hear a metallurgist speak in such language as this: "If the practical spirit—important and valuable as that is in its right place—is permitted to rule our research laboratories, it would be apt to sterilize our investigations and to rob us of the very fruit at which we should be trying to snatch."<sup>5</sup> And again we are warned by the same writer that "'research,' undertaken with a directly practical object, may actually hinder progress rather than assist it."<sup>6</sup>

Throughout all of these pages, however, the practical applications and inventions are treated as the real "fruits of science," which are to be attained in these devious ways.<sup>7</sup> "The game [in this particular case the useful knowledge of disease] has to be stalked from long distances and often by circuitous routes."<sup>8</sup> "Men who prove themselves especially adapted to purely scientific work must be subsidized in order that they may be able to devote themselves entirely to the task of scientific discovery."<sup>9</sup> *Why?* Because it is this "experimental investigation towards abstract ends which has furnished such gigantic contributions to the world's wealth during the past century."

In other words, it would seem that, even to this group of university scientists, the study of natural phenomena derives its ultimate justification from the useful by-products which it yields.

<sup>4</sup> Cambridge University Press, 1917.

<sup>5</sup> Professor Walter Rosenhain, p. 77.

<sup>6</sup> *Ibid.*, p. 56. See, also, similar remarks in address by Dr. C. E. Kenneth Mees, director of the Research Laboratory of the Eastman Kodak Company. (*Science*, June 2, 1916.)

<sup>7</sup> Professor W. H. Bragg, p. 25. This is also the burden of Ex-President Eliot's address on "The Fruits, Prospects, and Lessons of Recent Biological Science," delivered as president of the American Association for the Advancement of Science (*Science*, December 31, 1915).

<sup>8</sup> Lord Moulton, introduction, p. xvii.

<sup>9</sup> Professor W. J. Pope, p. 23.

We must remember, of course, that this volume was written during a great national crisis, when all the forces of the empire had to be mobilized for the purposes of defense. And we must remember too that the stagnant condition of the applied sciences in England was to a considerable extent responsible for her early military reverses. But with all due allowance for these circumstances, it seems to me that science has not received fair treatment at the hands of her own votaries.

The journal *Nature* has, for years past, been filled with stirring pleas for the public support of scientific investigation and scientific education in England. These pleas have doubtless been sadly needed, though there seem to be substantial reasons for hoping that the nation is at last becoming disposed to heed them. It is depressing, though perhaps at this time inevitable, that these appeals on behalf of science should rest their case mainly upon its contributions to the national wealth and national defense.

The friends of knowledge for its own sake will watch with the greatest concern to see whether these utilitarian motives will continue to dominate the scientific life of England now that the hour of peril has passed. For the war has really done nothing more than to accentuate a point of view which seems to have been gaining ascendancy for years past, in our own country as well as in England. We have long been accustomed to justify the comparative freedom which we sometimes accorded to our investigators on the plea that useful results turned up in all sorts of unexpected places, and that one could never tell in advance what lines of research would prove to be profitable. Add to this the unfortunate circumstance that the scientist was known to be an intractable sort of a being, who had to be allowed to gratify his perverse curiosity in order to keep him in the harness at all.

A writer in the New York *Evening Post* has expressed so well my own point of view in this connection that I can not refrain from quoting him rather fully. He says:

There can be no doubt that the gospel of relentless "efficiency" to which the war has given so great an impetus carries, deeply embedded in it the seeds of hostility to all activities and interests which find their spring in intellectual aspiration or enthusiasm. At best, from the standpoint of the efficiency cult, such endeavors have to be justified by the plea that, divorced as they may seem to be from practical objects, they do conduce to the advancement of the common ends of the nation or of mankind, though the connection may be remote or subtle. The plea can be made good over a very broad area. . . . But the argument is a thorny one; and that is not the worst of it. The mere necessity of resorting to



such a defensive plea, the mere surrender of the proud conviction that the pursuit of truth is in itself a noble end which requires no secondary justification, must immeasurably depress the tone of scientific enthusiasm and impair the energy with which its objects are pursued.

And it has to be confessed that, long before the war began, . . . another factor was working powerfully toward the production of the same effect. For years, and most of all in this country, the idea that "service" is the only justifiable motive of intellectual endeavor had been steadily gaining ground.<sup>10</sup>

Before detailing further the harmful results of such a utilitarian justification of science, let us pause to examine the philosophy which underlies it.

Those who hold this view of the mission of science in the world resort continually to such expressions as "usefulness" or "benefit to humanity." Now we might, it is true, so stretch the meaning of the word "useful" as to cover all of our so-called "spiritual" needs. Thus Professor Gamble tells us that "the function of pure science is to pursue *useful* knowledge," but he goes on to say that "by useful knowledge is meant knowledge which contributes to the moral, social, intellectual, æsthetic, and material welfare of mankind."<sup>11</sup>

Well, this may be what Professor Gamble has in mind when he uses the word "useful," but the world in general will not so understand him. As I have already said, such language merely tends to befog the issue. The "uses" and "benefits to humanity" which the public at large expects to derive from the labors of the scientist are inventions and applications to the practical affairs of life.

It is not at all evident why "fruits" of this type should be acclaimed as benefits to humanity, while weighty contributions to our understanding of nature should be put aside as mere luxuries of the mind. Nor can we comprehend why the author of a useful invention should be hailed as a philanthropist (in addition to the financial rewards which he receives) while the student of basic principles should be looked upon as a selfish recluse.

One is tempted, now and then, to affect an air of Socratic interrogation and to ask the *use* of some of these practical achievements. Suppose that we do, for example, succeed in shortening by six hours the journey from New York to Chicago, or in lengthening by five years the average span of man's life, or in making two blades of grass grow where one grew before. What shall we do with those extra six hours or five

<sup>10</sup> New York *Evening Post* (article reprinted in *Science*, March 2, 1917).

<sup>11</sup> "Science and the Nation," pp. 113, 114.

years, and what will the increased population do which is made possible by a greater food supply? It may all mean a merely *quantitative* increase in the total amount of living—by no means a self-evident advantage, according to my way of thinking. The great mass of humanity is engaged in discharging the purely vegetative functions of the social organism, in keeping alive the individual and the race, and in maintaining a certain low minimum of comfort. To merely increase the total amount of this vegetative activity in the world seems to be widely accepted as one of the chief goals of human endeavor. And this belief appears to underly much of the utilitarian appraisal of science.

Then too, what of all these achievements in the way of adding to our comforts and diminishing our sufferings and superfluous labors? Important as we may grant these to be, their value, after all, is largely of a negative sort. They consist, for the most part, in the removal of obstacles to a fuller life and higher development. They in themselves contribute but little directly to that development. The labors of the scientist, along with those of the artist, the poet, the philosopher and some others, do contribute directly to it. But our utilitarian defenders of science arrogate to themselves the credit for a broader humanitarianism than that which inspires the labors of the mere seeker for truth. The whole issue really depends upon one's conception of what is most worth while. Which is the higher aim—to make room in the world for the greatest possible number of human animals, or to make the world a more interesting and intelligible place to live in: to feed the belly or to feed the brain?

True it is that the alimentary needs must first of all be met, and that they are, for a large section of humanity, still quite inadequately provided for. But let us never forget that alim-entation is a means rather than an end, that the consumption of coal is not the real reason for the steam-engine's existence.

I can not leave this subject of the higher services of science without calling attention to an aspect of the matter which has received inadequate attention. Science has frequently been charged, not only with being irreligious, but with being unmoral, if not actually immoral in its tendencies. But strong arguments for the ethical value of science have been presented by various writers. Thus Professor E. P. Lewis, in an admirable recent article,<sup>12</sup> dwells upon the elevating effects of the scientific habit of mind on character.

<sup>12</sup> "The Ethical Value of Science" (SCIENTIFIC MONTHLY, November, 1918). See also address on "The Higher Usefulness of Science,"

The scientist has the same human failings as other people; he may have no better intentions nor be more righteous-minded than they; but he can sometimes act more intelligently in carrying out his good intentions. Science teaches us to seek the truth without prejudice; it develops the habit of disinterestedness; it leads us to consider all known elements in making ethical judgments; it prompts us to seek the amelioration of the health, the well-being, the happiness, of our fellow men; it diverts our vision from the fruitless contemplation of a past in which we can play no part to the present wherein lies our task; and it bids us to consider the future and the welfare of generations still unborn.

Professor Lewis points out, furthermore, the "real danger that too much stress may be laid on [the] material aspects of research, which are not science, but only its by-products." And he holds it to be "important for the interests of society that teachers of science should lay more emphasis upon its intellectual and ethical significance."

Let us consider further some of the baneful effects which may be expected to ensue from the adoption of this narrowly utilitarian view of the mission of science. It is generally agreed that the Great War is likely to have, as one of its sequelæ, a heightened activity along scientific lines. This, by many, is being acclaimed as part of that silver lining which every cloud is supposed to possess. But there are grave dangers in the situation, as I have already tried to indicate. For the kind of scientific activity which was stimulated by the war was inevitably utilitarian in the crassest sense of the word. The ends in view were military, industrial and sanitary. Researches along those lines which we rather inappropriately term "pure" science, suffered from the withdrawal of support and from the transference of the investigator's attention to more urgent needs. To what extent is this shifting of emphasis irreversible? The investigator who continues along the newer paths will doubtless be following the line of least resistance. He will have all the force of public approval behind him. And this is a powerful force when brought to bear upon a social being. The investigator may, to use the words of Dr. Raymond Pearl, come to "supplicate the great goddess Truth with one ear closely applied to the ground."

Again, the Great War has taught us, as never before, the power of organization. German organization came perilously near to conquering the world. It was only the tardy adoption of similar methods of organization by the Allied Powers that finally won the day for democracy. Hence it is that "individ-

by Professor W. E. Ritter, contained in volume having the same title (Richard Badger, 1918).

ualistic" ideas seem to be thoroughly discredited for the time being, and that something like a mania for organization is sweeping over the world, at least so far as we may judge from conditions in England and America.

Says Professor H. E. Armstrong: "Science must be organized, in fact, as other professions are organized, if it is to be an effective agent in our civilization."<sup>13</sup>

The editor of *Nature* tells us that

in no class of work involving many workers can we dispense with organization. An army is not a collection of armed individuals. . . . The present method of conducting scientific research is a go-as-you-please method, in which each man does what his own inclinations suggest to him or the means at disposal allow him to do. . . . We have to get rid, in every department of work . . . of waste, inefficiency and make-believe or valueless products. We have to get rid of them in scientific research as well. This can only be done by limiting the individual initiative and adopting greater and more carefully thought-out cooperation.<sup>14</sup>

The Committee of the Privy Council for Scientific and Industrial Research for the Year 1915-1916 voices the opinion that "effective research, particularly in its industrial applications, calls increasingly for the support and impetus that come from the systematized delving of a corps of sappers working intelligently, but *under orders*."<sup>15</sup>

A sub-committee of the Committee of One Hundred on Scientific Research, in our own country, thinks fit to point out, in referring to a staff of investigators in a research laboratory, that "the individual can exert only a very small influence except as a member of an organization or institution."<sup>16</sup> To this last assertion a critic has replied: "One wonders what institution or organization Newton or Darwin belonged to, without which 'they would have exerted only a very small influence.'"<sup>17</sup>

Now I do not intend to stultify myself by calling in question the power and the value of organization, at least when properly applied. The process of evolution, the passage from a lower to a higher state of being, is measured in terms of organization, and in this process the integrating or coordinating factor is no less important than the specialization of parts or of individuals.

<sup>13</sup> *Nature*, October 22, 1914.

<sup>14</sup> *Nature*, November 11, 1915.

<sup>15</sup> *Nature*, September 7, 1916 (*Italics mine*).

<sup>16</sup> *Science*, January 12, 1917. Such opinions could be multiplied voluminously. Some recently published remarks of Ex-Senator Elihu Root (*Science*, November 19, 1918), might be cited as extreme examples.

<sup>17</sup> *Science*, March 2, 1917 (anonymous).

But, as has often been pointed out, there are limits to the value of the conception of society as an organism. The biological organism acts as a unit, without any agreement of its parts so to act. There is but one guiding intelligence, which dominates the whole. Society, on the contrary, possesses as many intelligences as there are individuals, even though many or all of these may think best at times to surrender their own freedom of judgment and to be guided by the decisions of others. Society may act as a unit, but it can never think as a unit. This is true even in those rare cases when most of its component members chance to be stirred by the same idea. However much one mind may influence another, thinking is an individual and not a collective function. And we are all agreed as to the homage due to the genius, whose mental achievements owe the least to suggestions from his fellow men.<sup>17a</sup>

Intellectual activities may be "organized," of course, in the sense that a group of individuals may cooperate toward the attainment of some specified end. And it may at times further this common cause if the component minds delegate a certain part of their own initiative to some higher "coordinating center." Such an arrangement as this, indeed, may be the most efficient way in which to utilize the activities of a group of mediocre minds. But it is obvious that what is gained in collective efficiency is lost in individual spontaneity. The arguments by which we seek to justify democracy versus autocracy, in political life, apply to a large extent here. Be that as it may, it is significant to note that practically all of the really revolutionary discoveries in the history of science have been made by individuals, working not in solitude, it is true, but likewise not bound by any scheme of cooperative effort, involving others than themselves.

One of the chief risks inherent in any extensive cooperative scheme of scientific research is the fact that one may readily come to spend most of his time in "cooperating," and have little time left for the discovery of facts. Another grave danger has been pointed out clearly by various recent writers. Organization may readily open up the way for the activities of a type of executive whose influence is largely inimical to the true spirit of science. This executive may be a more or less successful man of science who becomes ambitious for wider powers, or he may belong to the purely administrative or business class. In either case, he is likely to be autocratic in his

<sup>17a</sup> I am not aware that any serious attempt has been made to *organize* the creative efforts of our painters, poets or musicians.

temper, and to regard the organization over which he presides as an instrument for carrying out his own ideas. If, as may well happen, these ideas contemplate real advances in scientific knowledge, the chief damage done is to the morale of the investigators, whose powers of original work can not fail to be impaired.

But if we have to do with the purely business type of executive, matters will be far worse. Such a one is almost certain to be a utilitarian, in the sense in which I have been using this term. That is, he will look upon scientific research as justified merely by its direct or indirect practical results. He will apply business criteria in his estimates of the men under his supervision, and will grade them in large degree according to the salaries which they are willing to work for. He will be disposed to assign an undue importance to his own administrative function, and to think of the investigators under him in much the same way as the factory superintendent regards the "hands" who operate the machinery.

So extreme a condition as this is, it is true, probably seldom realized. Such an executive would soon learn by experience, even if his business instincts did not teach him better at the outset, that a state of affairs like this would defeat his own ends. But, subject to such modifications as a higher prudence would dictate, the general situation could not fail to be much as I have outlined it. Indeed, it is safe to say that conditions approaching this have been realized over and over again in our state or national research institutions and even in some of our universities.

Let me quote the words of a man who, as we all know, is no mere doctrinaire scientist, but who himself holds a responsible administrative post. Dean Eugene Davenport, of the Illinois Agricultural Experiment Station, has devoted several pages to a scathing indictment of what he terms the "cult of administration."<sup>18</sup>

"The rate and the intensity with which administration under one pretext or another is coming to dominate research in this country, especially along agricultural lines, is," he tells us, "little short of appalling to any candid observer who takes stock of the situation and who has the courage of his convictions." He then proceeds to narrate in picturesque terms how the investigator's hands are tied and his spirit crushed by the exacting demands of officialdom.

<sup>18</sup> Address of the chairman of Section M (Agriculture) of the American Association for the Advancement of Science (*Science*, February 16, 1917).

In summing up the situation, he insists—this practical man of affairs—that

administration can not vitalize research. Its whole effect is restrictive and hence should be reduced to a minimum. . . . All progress in science is the result of individual interest, initiative, invention and energy, all of which must be resident in the worker. The driving force that brings results is internal, not external, to the explorer after new truth. It beckons from ahead and does not prod from behind. . . . Administration does no work. It is a harness put upon activity. Its purpose is not to actuate, but to restrain and forbid. . . . The effect of too much administration upon the scientific worker is at first one of disappointment, then of discouragement, and finally of disgust. Conditions as they are now developing not only constitute an unhealthy example for our young men in college, but they are deterring thoughtful men from entering the public service.

Modern efficiency standards are not applicable to research. "Under what project," queries this same writer, "did Darwin work? Did Faraday report regularly upon the progress of his mental wanderings after firm resting places?"

Now that much heralded "cooperation in science," which is to regenerate the world, might not of necessity bring in its wake all of these evils of administration which Dean Davenport depicts. But there can not fail to be a strong tendency in that direction. All this may be said with a full recognition of the necessity for that stimulus which comes alone from contact with others having kindred interests. Isolation means intellectual stagnation. "The solitary scientist is likely to put a great part of his life into pathetic futilities" (Elihu Root). It is inconceivable that any group of specialists in allied fields should be thrown together in close association without there resulting much valuable interchange of thought, even if this did not take the shape of actual formal collaboration in their researches.

We may go further and grant that many important problems of science can only be solved through deliberate, cooperative effort, and that the extent and importance of such cooperation is bound to increase with the growth of civilization. But the dangers of this tendency should none the less be fully recognized. In general, it would seem that each case should be decided upon its own merits. Those who contemplate any particular cooperative program should, it seems to me, first ponder well the question whether the increasing degree of administrative routine and the suppression of individual initiative would not more than outweigh any compensating advantages.

In these days of national prohibition, press censorship and

espionage acts, I realize that "personal liberty" is no longer a slogan which will arouse much public enthusiasm, and I am quite aware that "individualism" and "*laissez-faire*" have latterly become terms of reproach. But there seems to be a decided danger that we may go to the opposite extreme. I have before me an article in the *Independent*<sup>19</sup> by a prominent university president, and another in the *New York Times*<sup>20</sup> by an anonymous "university professor now in the service of the United States." Both discuss the recent reorganization of American universities in the interests of the Students' Army Training Corps. And both voice the fervent hope that this experiment in militaristic paternalism will be continued indefinitely after the close of the war.

Indeed the writer in the *New York Times* assures us with the utmost complacency that it *will* be continued. Young men—and women too—will henceforth be drafted as paid cadets into our universities, which will remain governmental institutions. The courses pursued by each of these "student soldiers" will be prescribed according to his individual needs and abilities, and "non-essentials," or subjects for which he is not particularly fitted will be stricken from his curriculum. Upon the rating which he scores in his various tests of ability will depend, not only his military rank in the great citizen army, but his preparation for a business or professional career. "Nor will a professor, who [as an army officer] has learned to command and to obey, allow the old easy-going *laissez-faire* doctrine to permeate his lecture hall or laboratory," for military discipline, now that we have learned it, "won't soon be forgotten even in our classrooms." This "all looks like a Utopian scheme," concludes our writer, "but already we are doing it, and acquiring the habit."

Heaven help this Republic if our sons and daughters are to be trained for life as khaki-clad marionettes!

What, then, seems to be the duty of the man of science in the face of these dangers which threaten him both from within and without? To begin with, I should say, he should have the courage of his convictions. There is no question that he has often wavered in his faith in the importance of his own mission. The competent investigator who decides to practice medicine or to undertake elementary teaching for the reason that

<sup>19</sup> October 5, 1918. In a later article (Dec. 14, 1918), President Thwing has, it is true, laid considerable emphasis upon some of the "losses in educational values arising from this revolution."

<sup>20</sup> October 20, 1918.



he "wants to do some good in the world," may be actuated by praiseworthy motives, but he is sadly lacking in appreciation of his own high calling.

Once more, unless his real interests and abilities lie in the field of practical application, the scientist should steadfastly refuse to compromise with the utilitarian spirit, even though he thereby forfeits social recognition and financial support.

With the reinforcements which the developments of the war have from so different a quarter brought to this tendency, it is more than ever necessary for those to assert themselves who know how precious to the life of us all is that element which is supplied by the devotion of the lives of some to the pursuit of truth for its own sake, or even for the sake of the fame which is the natural reward of signal success.<sup>21</sup>

Let those few fortunate ones who control the disposition of funds given without hampering restrictions sturdily refuse to divert these funds to utilitarian ends. A glance at the budgets of some of the organizations engaged in industrial and agricultural research in this country is conclusive proof that this type of investigation may be trusted to take care of itself.

There are, we are reliably informed, upwards of fifty corporations in this country, the annual expenditures of which on research range from \$100,000 to \$500,000.<sup>22</sup> The General Electric Company expends annually on research from \$400,000 to \$500,000, and has a laboratory staff numbering 150. The laboratory of the Eastman Kodak Company cost \$150,000, and its annual cost of maintenance is about the same. The Mellon Institute of Industrial Research spends \$150,000 annually on salaries and maintenance, and its buildings and equipment cost over \$300,000.<sup>23</sup>

Passing to those of our government departments which conduct scientific investigations, the Department of Agriculture, in 1915, spent about \$25,000,000, largely for research and education; the Bureau of Standards is said to spend annually about \$600,000; the Bureau of Mines a nearly equal amount, and certain other bureaus expend smaller, though very considerable, sums.<sup>24</sup> Our 52 state agricultural experiment stations have a total revenue of some \$5,000,000 annually.<sup>25</sup>

How trifling, in comparison with these immense sums, are the amounts which are devoted to the quest of knowledge with-

<sup>21</sup> New York *Evening Post*, quoted in *Science*, March 2, 1917.

<sup>22</sup> *Nature*, March 23, 1916.

<sup>23</sup> *Nature*, August 9, 1917. More recent figures are not accessible to me, but these expenditures have doubtless increased.

<sup>24</sup> *Nature*, May 31, 1917.

<sup>25</sup> *Ibid.*

out ulterior ends! To jealously guard that little from the encroachments of utilitarianism can not reasonably be imputed to any spirit of hostility to the practical utilization of scientific discovery. I think it the only tenable position at present for one who has a proper conception of the worth of science and who realizes the dangers which beset it.

Finally, it is the duty of the scientist to assume responsibility, as never before, for the enlightenment of the public upon the aims, the achievements and the real value of science. In this educational appeal, let him lay his chief stress upon the steady deepening of our insight into nature and life which science has given us. Let him show, as he of all persons should be best capable of showing, the bearing of his own special discoveries upon these wider realms of knowledge. But let him set aside once for all the wretched make-believe that these discoveries derive their real justification from the fact that they may in some remote way help to stimulate invention or put money into some one's pockets!